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# FROM AUTONOMOUS TO PERFORMATIVE CONTROL OF TIMBRAL SPATIALISATION

Stuart James

West Australian Academy of Performing Arts  
Edith Cowan University

## ABSTRACT

*Timbral spatialisation is one such process that requires the independent control of potentially thousands of parameters (Torchia, et al., 2003). Current research on controlling timbral spatialisation has focussed either on automated generative systems, or suggested that to design trajectories in software is to write every movement line by line (Normandeau, 2009). This research proposes that Wave Terrain Synthesis may be used as an effective bridging control structure for timbral spatialisation, enabling the performative control of large numbers of parameter sets associated with software. This methodology also allows for compact interactive mapping possibilities for a physical controller, and may also be effectively mapped gesturally.*

## 1. INTRODUCTION

Timbral spatialization techniques are ways of dispersing a sound in space by placing each component frequency sub-band in a different localised position across a multichannel speaker array.<sup>1</sup> The technique has its origins established not only in spatialisation theory, but also in FFT<sup>2</sup> techniques and granular synthesis. In an abstract sense both FFT and granular techniques use a windowing technique to reduce sound into smaller

constituent components. These components or *particles*<sup>3</sup> of sound are broken down either by their relative frequency or position in time. They may be described as spectra in the frequency domain, and as grains or quanta of sound in the time domain. Timbral spatialisation effectively extends this process to allow for the independent panning of individual spectra, allowing a performer and/or software to “re-sculpt” a sound both timbrally and spatially. This technique can be applied to the re-synthesis of spectra derived from recorded sounds<sup>4</sup>, and may also be applied to tones generated synthetically.

Timbral spatialisation opens up the possibility of re-composing sounds in terms of timbre and space, and exploring this technique in a performative sense may allow the performer/composer to explore concepts such as Ligeti’s concept of *permeability* where the individuality of timbre and interval give way to a more abstracted and chaotic, and increasingly difficult texture.<sup>5</sup> The underlying intent here in exploring timbral spatialisation in a performative sense, is to explore modifications on live sampled input, and to explore the timbral and spatial transformation that occurs through this interaction. This allows for a realtime acousmatic representation of these familiar sounds. As Smalley has written on spectromorphology:

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<sup>1</sup> Schmele, T. 2011. Exploring 3D Audio as a New Musical Language. Masters Thesis. *Music Technology Group, Department of Information and Communication Technologies, Universitat Pompeu Fabra*

<sup>2</sup> FFT being the Fast Fourier Transform, a term more often used in realtime frequency domain synthesis, bearing in mind this is an efficient computation of the discrete fourier transform or DFT.

<sup>3</sup> The “quantum of sound” was first written about by Gabor in 1947. He proposed some early theories that were to be later coined granular synthesis by Xenakis in his text *Formalized Music* (Xenakis, 1971). Curtis Roads later described the compositional practice centered around the use of grains *Microsound*. Whilst Granular Synthesis should not be confused with frequency domain synthesis, there is a parallel in the sense that both techniques employ windowing techniques and the opportunity for sounds to be reconstructed either in the frequency domain or the time domain.

<sup>4</sup> Torchia R, and Lippe, C. 2003. “Techniques for Multi-Channel Real-Time Spatial Distribution Using Frequency-Domain Processing.” *Proceedings of the International Computer Music Conference, Singapore*: 41-44.

<sup>5</sup> Ligeti, G. 1965. “Metamorphoses of Musical Form,” *Die Reihe*, (ed.) K. Stockhausen and H. Eimert, (trans.) by C. Cardew, Bryn Mawr: Theodore Presser: 5-11.

The wide-open sonic world of electroacoustic music encourages imaginative and imagined extrinsic connections because of the variety and ambiguity of its materials, because of its reliance on the motion of colourful spectral energies, its emphasis on the acousmatic, and not least through its exploration of spatial perspective (Smalley, 1997).

Such techniques of spectral synthesis and decomposition within the performance space evoke notions of Schaeffer's analytical (or 'reduced') listening mode, yet here they are realised through the process of sound diffusion.<sup>6</sup> Careful selection of sound sources can make spatial percepts a compositional area to explore.<sup>7</sup> With natural sound sources, whose timbre's are dependent on features such as attack transients, the spatial re-distribution of a sound's spectral content can be an especially interesting musical effect.

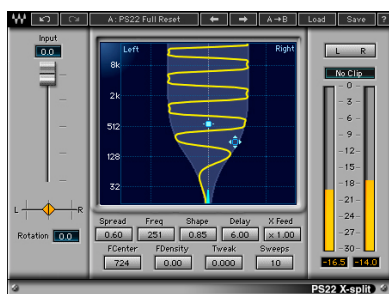


Figure 1. The Waves PS22 Mono-to-Stereo Plugin

Out of the many approaches to spatialisation, including developments in ambisonics and wavefield technology, Dolby and DTS surround encoding and decoding processes, binaural and head-related transfer function methodologies in 3d-audio, and rapid panning modulation synthesis, timbral spatialisation focuses largely on the localization of spectra with respect to azimuth in the median plane.<sup>8</sup> Early implementations of such a concept arose in some mono-to-stereo tools such

as the Waves PS22 plugin allowing the engineer to shift the relative position of various frequency bands between two speakers resulting in a pseudostereo<sup>9</sup> effect.

Timbral spatialisation methodology largely draws on the fundamental theories of sound localization established by Blauert, namely the perception of localization based on a sounds *Interaural Time Delay* and *Interaural Level difference*.<sup>10</sup> Recent interest in spatialisation systems has also seen new research into the gestural control of spatialisation techniques.<sup>11</sup> However, in the case of timbral spatialisation Normandeau states:

At the moment, the only way to design trajectories in... [software]... is to write every movement line by line, which is not adequate for complex movements. (Normandeau, 2009)

Currently implementations of control for timbral spatialisation have been limited as compared to many other techniques.<sup>12</sup> Previous implementations have employed the use of automated or pre-composed systems such as drawing the spatialization or using feature analysis from other sound sources creating a spatial cross-synthesis.<sup>13</sup> Building on the work of Torchia and Lippe in 2004, Kim-Boyle also used the boids algorithm to determine the spatial location of each frequency band, and later also used simulations of clouds of smoke.<sup>14</sup> More recently Barreiro has simplified the control of such a system by reducing the system to 8 frequency bands for adopting a more static and simplified method of control.<sup>15</sup>

Interestingly Barreiro reports a strong dependence on the input sound for the success of the technique:

In general, sounds with a broad spectral content tend to sound diffused, providing an enveloping sonic image. Sounds with energy concentrated on specific regions of the spectrum, on the other hand, usually sound more localised." (Barreiro 2010)

<sup>6</sup> Smalley, D. 1997. "Spectromorphology: Explaining Sound Shapes." *Organised Sound: Vol. 2, no. 2. Cambridge: Cambridge University Press:* 107-126. and Lauke, K. and E. Stefani. 2010. "Music, Space, & Theatre: Site-specific approaches to multichannel spatialization." *Organised Sound*.

<sup>7</sup> Kendall, G. 2007. "The Artistic Play of Spectral Organization: Spatial Attributes, Scene Analysis and Auditory Spatial Schemata" *Proceedings of the International Computer Music Conference*, Copenhagen: 63-68.

<sup>8</sup> Normandeau, R. 2009. "Timbre Spatialisation: The Medium is the Space." *Organised Sound* 14, no. 3.

<sup>9</sup> Such pseudostereo methods are discussed in Streicher, R. and F. A. Everest. 2006. *The New Stereo Soundbook: Third Edition*. TAB Books: Audio Engineering Associates, California

<sup>10</sup> Blauert, J. 1969. "Sound localization in the median plane," *Acoustica* 22: 205-213.

<sup>11</sup> Marshall, M. T., J. Malloch, and M. M. Wanderley. 2009. "Gesture Control of Sound Spatialization for Live Musical Performance." *Gesture-Based Human-Computer Interaction and Simulation: 7th International Gesture Workshop, GW 2007, Lisbon, Portugal (2007)*, Revised Selected Papers, Springer-Verlag, Berlin, Heidelberg.

<sup>12</sup> Kim-Boyle, D. 2008. "Spectral Spatialization: An Overview." *Proceedings of the International Computer Music Conference*, Belfast.

<sup>13</sup> Torchia R, and Lippe, C. 2004. "Techniques for Multi-Channel Real-Time Spatial Distribution Using Frequency-Domain Processing." *Conference on New Interfaces for Musical Expression (NIME)*, Hamamatsu, Japan: 116-119.

<sup>14</sup> Such as jit.p.vishnu, jit.p.shiva and jit.p.bounds; Refer to Kim-Boyle, D. 2008. "Spectral Spatialization: An Overview." *Proceedings of the International Computer Music Conference*, Belfast.

<sup>15</sup> Barreiro, D. L. 2010. "Considerations on the Handling of Space in Multichannel Electroacoustic Works", *Organised Sound* 15(03), 290-296.

In 2011 James suggested that Wave Terrain Synthesis may be used as a means of controlling timbral spatialisation, rendering such a complex processing system more manageable in live performance.<sup>16</sup> It is arguable that both the multi-dimensionality, transformational, and morphological nature of Wave Terrain Synthesis is synonymous to the kinds of transformations needed for controlling timbral spatialisation. Wave Terrain Synthesis is also simple and effective to control, especially when mapped to gestural controller input.<sup>17</sup> Using Wave Terrain Synthesis as a method of controlling timbral spatialisation allows a performer to sculpt the localisation of many individual frequency bands with a comparatively small number of control parameters.

## 2. REALTIME AUTONOMOUS CONTROL

Whilst the motivations of this project have extended to many different areas in the field including techniques involving sound spatialisation, table lookup, FIR filtration, convolution synthesis, as well as concepts such as multi-dimensionality, timbre (i.e. tone color and spectrum), phase quadrature, evolution, trajectory, morphology, transformation, and gesture, the concept originally in mind was to give a performer a simple tool from which they could push and pull frequencies from one location in space to another. The most obvious of these that initially evolved was an idea of biasing high frequency in one direction and low frequency in another. If we were to replicate this on a 2-speaker system using two 30-band equalizer's for each speaker, we would achieve this bias by inverting one of the filter curves across the horizontal axis as we see in Figure 2. In a way this is synonymous with the concept of a linear crossfade, as effectively all we are doing is shifting a frequency band out of one signal and boosting it proportionally in another. When this process occurs, psychoacoustically we perceive a frequency band moving from the "centre" of a stereo image, and off to the side.

In software these kinds of filters are often implemented in the frequency domain, and referred to as FIR filters. Instead of a global linear crossfade controlling the overall amplitude of the resulting sound, we have many virtual faders that are each independently determining the amplitudes of each respective frequency band:

$$A_{amp} = \frac{\theta}{\theta_{MAX}}$$

$$B_{amp} = 1 - \frac{\theta}{\theta_{MAX}}$$

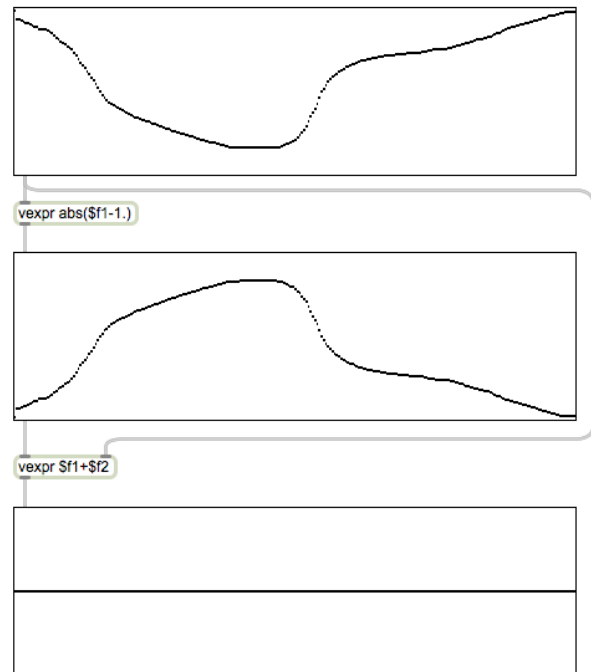


Figure 2. A multi-band filter curve, it's inverse curve, and the two curves added together showing equal distribution of energy

The importance of "phase" and "inverted phase" are important here, as the intended idea is that if each fader level for both channels is added together, and compared to all other fader levels, the accumulated energy should be constant for all frequencies as we see in the final graph in Figure 2.<sup>18</sup>

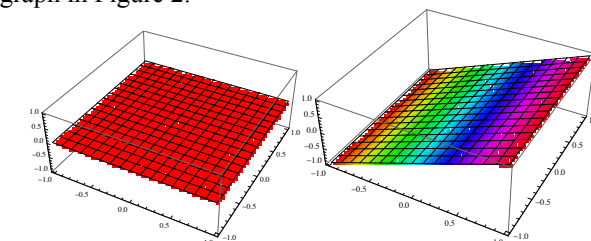


Figure 3a. Signal equally spectrally distributed out to all loudspeakers  
Figure 3b. Signal is distributed out to the loudspeakers in such a way that the sound spectrally shifts from low to high frequency across the room.

By extending this system to use 2-dimensional wave surfaces, we are merely controlling the way frequencies are distributed by manipulating a virtual plane. So how do we result in two signals that are effectively opposite "polarity" or 180 degrees out-of-phase? We can achieve this using a circular orbit, reading values off the 2-dimensional plane while following this circular orbit. In figure 4a we can see our circular orbit. One trajectory effectively begins from point A, and the second

<sup>16</sup> James, S. 2011. "Multidimensional Data Sets: Traversing Sound Synthesis, Sound Sculpture, and Scored Composition." *Proceedings of the Australasian Computer Music Conference, Auckland.*

<sup>17</sup> Mills, A. and R. C. De Souza. 1999. "Gestural Sounds by Means of Wave Terrain Synthesis." *Congresso Nacional da Sociedade Brasileira de Computação XIX.* [http://gsd.ime.usp.br/sbcm/1999/papers/Anderson\\_Mills.html](http://gsd.ime.usp.br/sbcm/1999/papers/Anderson_Mills.html)

<sup>18</sup> We in fact require an equal power panning curve to ensure that different frequency bands move between the speakers with an equal power relationship maintained. This may be easily remedied by reshaping the amplitude settings for all frequency bins using a transfer function

$$w(t) = \sin\left(\frac{\pi}{2}t\right)$$

trajectory begins at point B. Both move in an anti-clockwise direction. The advantage of this system is we can rotate the terrain or the trajectory any number of times, and the phase relationship of A and B remain the same.

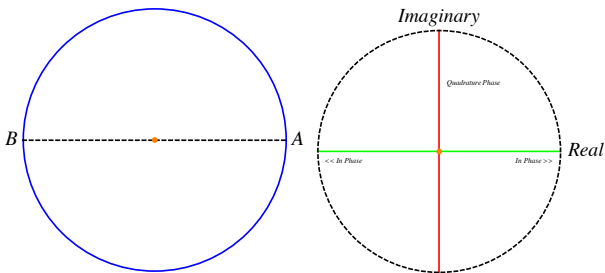


Figure 4a. A circular trajectory structure used to lookup values over a 2-dimensional plane. Whilst only one trajectory is generated, a phase displaced version of this trajectory is used for looking up values over the 2-dimensional plane for the second loudspeaker.

Figure 4b. A graphical representation of the Hilbert Transform.

Generating a circular trajectory orbit is achieved by a well-known process described scientifically as the Hilbert transform. This is achieved by mapping our original “real” signal against the same signal displaced in quadrature phase or a 90 degree phase shift.

Visualising the trajectory has been achieved by writing the trajectory to a jitter matrix allowing the performer to track the trajectory on a video display. Whilst the output is broken periodically with a clear message, the changes over time are smoothed with the use of video feedback; this smooths the transitions over a period of time, creating changes that naturally decay over time. This is visible in Figure 5.

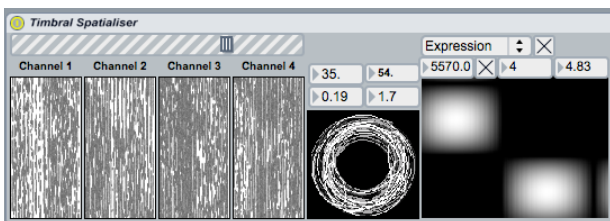


Figure 5. A version of the timbral spatialiser created for Max4Live. The trajectory is plotted in the centre of the interface. To the right of this is the terrain contour, and the left-most part of the patch shows the changing spectrum for all 4 output channels.

In a four speaker system, we phase shift the second, third, and fourth signals by 90, 180, and 270 degrees respectively. We can view this phase shift in Figure 6. As we know the exact number of samples in one single periodic revolution of our trajectory, we are able to specify the phase shift as an exact number of samples delay. If our FFT window size is 2048 samples, this gives us a revolution of exactly 1024 samples which, if our sampling rate is 44100Hz then our fundamental frequency is approximately 43Hz. This also translates to a signal delay of 256 samples, 512, or 768 respectively.

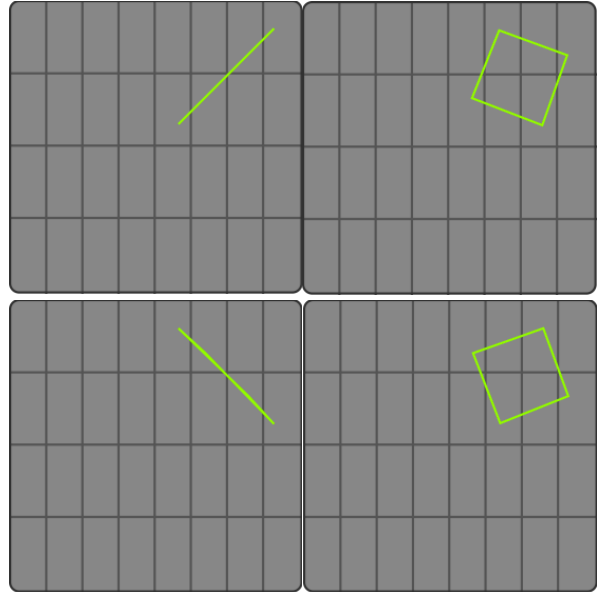


Figure 6. Plots showing the phase divergence of each signal. Top-left is in phase (0 degrees), top-right is 90 degree's out-of-phase. Bottom-left is 180 degree's out-of-phase. And bottom-right is 270 degree's out-of-phase.

Similarly in an eight speaker system, we extend the phase shift to 1/8, 1/4, 3/8, 1/2, 5/8, 3/4, and 7/8 to create 8 discreet outputs. We can use a series of delays at 128, 256, 384, 512, 640, 768, and 896. Figure 7 shows the phase distribution of 4- and 8-channel speaker configurations used.

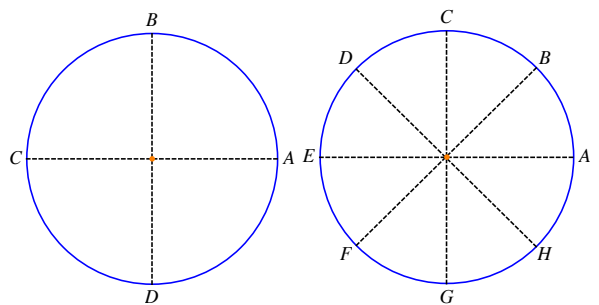


Figure 7. Plots showing phase distribution of speaker channels. To the left we have a quadrasonic configuration A, B, C, and D where A and B are front right and left, and C and D are rear left and right channels. To the right we have a plot showing phase distribution for 8 channels. Again these follow in series in an anti-clockwise direction.

Advantages for this mapping strategy include the ability to tilting the terrain structure resulting in a spectral divergence, rotation of the terrain and/or trajectory resulting in a rotation of a specific frequency distribution in a circular speaker array, scaling adjustment of the trajectory signal correlates to spatial separation, geometric contortions of the terrain and trajectory structures result in effective translations spatially, haptic rate dynamics can be introduced using dynamic terrain surfaces (i.e. motion video), and audio rate timbral spatialisation can be achieved by modulating the trajectory signal.

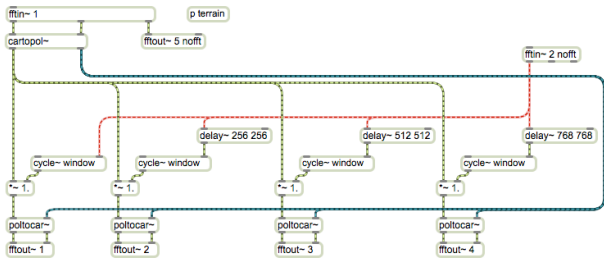


Figure 8. The internals of the FFT sub-patcher; this patch manages the phase shift applied to the filter contour, and calculates the component frequencies to be sent out to each speaker.

To some extent this method does create a significant amount of timbral “spill” between all speakers, so it was also necessary to devise ways in which to make the spectral bands between each speakers narrower and more precise. This was achieved by implementing spectral gates, a method where the performer is able to specify a threshold through which frequencies can be allowed through. At sensitive settings the system lets through everything, but at more insensitive threshold settings the system only allows frequencies through at higher energies or amplitudes.

Another method was to create window functions for each speaker that “narrow” the spectral window being read from the terrain or plane. This way the curve is determined by a smaller arc rather than a full circumference of the circle.

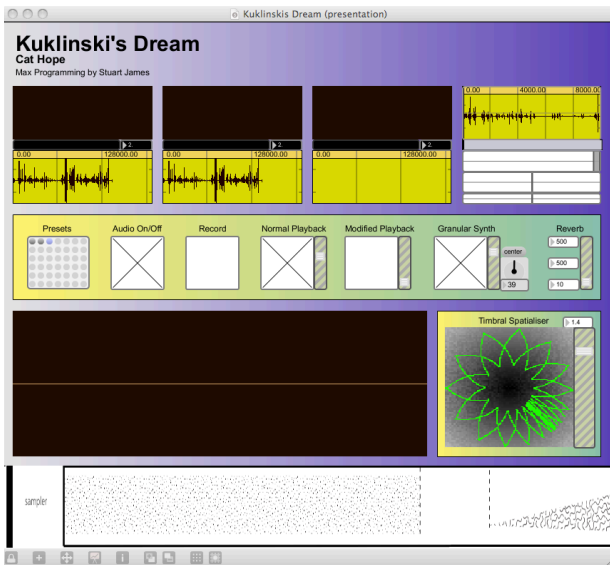


Figure 9. The interface for “Kuklinski’s Dream”, a composition by Cat Hope. This patcher designed by Stuart James uses automated timbral spatialisation as a means of dispersing sound about a quadraphonic system.

### 3. SPATIAL TRANSFORMATION VERSUS GEOMETRIC TRANSFORMATION

Previous research has also focused on transformational processes applied to both the terrain and trajectory structures.<sup>19</sup> The potential for using terrain surfaces that exhibit random and “noisy” topographies translate to a resulting control contour that exhibit these same sorts of characteristics. Further transformational processes have included video feedback and spatial remapping, as well as geometric transformation of the trajectory structure using processes such as affine transformation, filtration, bit-rate reduction, and delay lines. In a way audio filters (in the IIR sense) create a sculpting tool for audio not too dissimilar to the blur and sharpen tools we find in graphics. We can use these filters to change the shape of our control signal.

It is these geometric transformational processes that can extend the scope of this methodology in performance. By using Wave Terrain Synthesis as a bridging control in this way we have the opportunity to morph and contort the behavior of another audio process; for example these geometric transformations may be used to twist, push and pull the timbre spatially. In terms of gesture to sound mapping, Mills and De Souza explored the slow translation of these trajectory orbits over a terrain surface, and found this to be effective in creating expressive control.<sup>20</sup> However with the additional extensive range of transformational parameters here, there is further scope and increased flexibility in how gesture may influence sound via such a model. Exploration of this mapping flexibility will be a major focus of investigation in this research project.



Figure 10. In the top-right we see a geometrically contorted version of the image found in the top-left. The bottom-left and bottom-right show a virtual 3-dimensional plot of both images above.

<sup>19</sup> Roads, C., et al. 1996. *The Computer Music Tutorial*. Cambridge, Massachusetts: MIT Press and James, S. 2005. “Developing a Flexible and Expressive Realtime Polyphonic Wave Terrain Synthesis Instrument based on a Visual and multidimensional methodology.” (Masters Diss., Edith Cowan University).

<sup>20</sup> Mills, A. and R. C. De Souza. 1999. “Gestural Sounds by Means of Wave Terrain Synthesis.” *Congresso Nacional da Sociedade Brasileira de Computação XIX*, [http://gsd.ime.usp.br/sbcm/1999/papers/Anderson\\_Mills.html](http://gsd.ime.usp.br/sbcm/1999/papers/Anderson_Mills.html)

#### 4. PERFORMATIVE CONTROL

The physicality of the human body in electronic music performance is still often seen to be a fundamental missing element in electronic music.<sup>21</sup> In comparison to other performance practices, audiences of electronic music performances often find it hard to relate the physical gestures they see with the auditory outcome they hear.<sup>22</sup> Machines do not interpret movement in the same way human beings observe and experience it. As Camurri and Moeslund state:

Human beings seem to have little or no problem with perceiving and understanding the expression of gestures of musical performers and dancers on a scene. Even when we are not able to see all details of the performers' movements and/or bodies, ...we also perceive parts of the body that may be momentarily occluded because of an unfavourable viewing angle, i.e. we will in most cases correctly assume that a person continues to move the whole body even though we actually only see some parts of the body moving. Our abilities to sense quite accurately both the actual movements and their expressive and emotive features become even more remarkable when we try to replicate these abilities with machines. What's easy for us may be very difficult or even impossible for machine-based systems of vision. Yet developing technologies for machine-based vision and gesture recognition has attracted considerable effort, because such artificial systems of vision and gesture recognition may have many applications in human-computer interaction (HCI) (Godøy, et al., 2009, p238).

The process of gesture to sound mapping has many possibilities, but in performance practice there are additional aesthetic considerations. The performers physical engagement with software relates to the theatre of live performance. There has been much recent work involved with the analysis of musician's posture and gestural movement during performance.<sup>23</sup> This has involved not only the scientific analysis of gesture to sound but also the psychology of the performers physical experience, and how this translates to musical expression.

Recent developments in computer hardware have started to redefine how we physically interact and engage with technology. With the introduction of multi-touch devices like the Jazzmutant Lemur, Apple iPhone and iPad, it is possible for a performer to access different functions directly via a customizable graphical user interface. Other sensory technology such as the Vicon motion camera can track the form and movement of the physical body in 3-dimensional space. The Xbox Kinect is another motion capture device that uses infrared light with depth perception allowing for the capture of 3-dimensional movement and acceleration of the human

body in space. Many of these technologies allow for a more diverse interpretations of body movement and gesture.

With the use of tactile multi-touch technologies such as the iPad, the intention here is to extract control information from hand gestures and movement which will then in turn be used to geometrically contort terrain and trajectory structures used by Wave Terrain Synthesis to then in turn generate control information for timbral spatialisation. In this way Wave Terrain Synthesis serves as a software control bridge. Refer to Figure 11 for a schematic. This process will effectively modulate the parameter sets generated by Wave Terrain Synthesis allowing to expressively control many different parameter streams simultaneously. As noted in the abstract, timbral spatialisation requires potentially thousands of control parameters, and to make this process ideally responsive, these control signals must operate at audio rate.

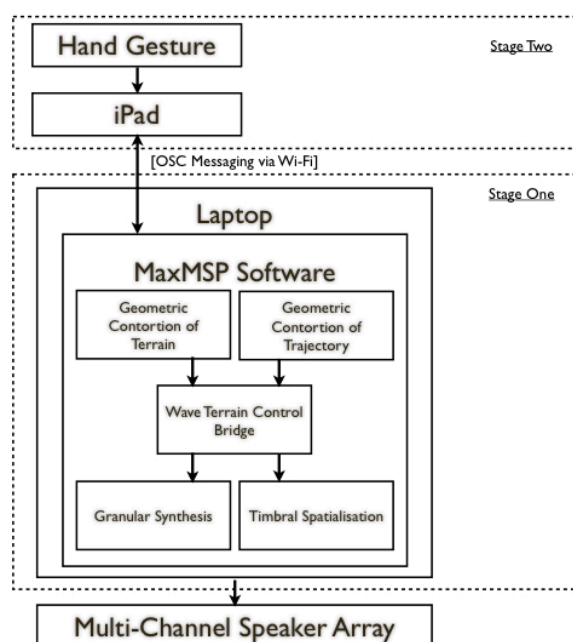


Figure 11. A schematic outlining how both the iPad controller and software are bridged, bearing in mind that Wave Terrain Synthesis bridges the iPad to the timbral spatialisation.

An effective physical controller for these kinds of transformations requires a multi-sensory device. Hsu has explored the use of the Wacom Tablet for the purposes of drawing trajectory structures<sup>24</sup>, but new technologies are emerging that promise new directions through customisable multi-sensory and tactile control such as the Arduino, as well as mobile and programmable multi-sensory devices such as the Apple iPhone and iPad. Finding effective ways and means of gesture mapping for trajectory motion and how to effectively generate

<sup>21</sup> Turner, T. "The resonance of the cubicle: Laptop Performance in Post-Digital Musics." *Contemporary Music Review* 22, no. 4 (2003): 81-92.

<sup>22</sup> Stuart, C. "The object of performance: Aural Performativity in Contemporary Laptop Music." *Contemporary Music Review* 22, no. 4 (2003): 59-65.

<sup>23</sup> Kapur, A., G. Tzanetakis, N. Virji-Babul, G. Wang, and P. R. Cook. "A Framework for Sonification of Vicon Motion Capture Data" *Proceedings of the International Conference on Digital Audio Effects*, Madrid, Spain (2005).

<sup>24</sup> Hsu, W. 2002. "A Flexible Interface for Wave Terrain Synthesis." *PERformance & NETworking Colloquia*, San Francisco State University, Department of Computer Science. <http://cs.sfsu.edu/news/pernet/02/04-24-02.html> and <http://userwww.sfsu.edu/~whsu/TERRAIN/>

and/or manipulate a terrain surface strikes right at the heart of effectively performing using this method. The choice of physical controller or sensor is critical in being able to effectively map gestural information from a performer. A Polhemus Stylus or similar device provides position and orientation information for a single point in space via a stylus tip, whilst a gesture interface can input many positions since the system tracks multiple features simultaneously. Further investigation will involve experimentation with two dimensional and three dimensional motion cameras such as the Vicon and Kinect interfaces to test their complementarity with the traversal of multi-dimensionality. This is a topic for further discussion at a later stage.

The way in which these processes are mapped will determine exactly what auditory process the movement determines. For example, hand and arm gestures may influence the shape and course of the trajectory. In this way body movement will effect the multichannel imaging and distribution of frequencies, pulling them around in a more abstract sense. As a means of clarification, the term sound sculpture could be used here loosely to describe the physical act of sculpting a terrain surface with physical input much like Dan Overholt explored with the MATRIX interface.<sup>25</sup> Since the terrain largely affects the resulting sound, the perceived effect here is such that the performer is “sculpting” the sound gesturally via such a process.

Advantages of the iPad as a controller device include the fact that it is multi-touch, wireless, it has a software development kit available, a proliferation of different apps intended for controlling music software remotely,<sup>26</sup> it uses OSC (open sound control) as a protocol. There are also music controller apps where the user interface is completely programmable such as TouchOSC<sup>27</sup>, MrMr, C74, and Ardumote HD.

One major distinction to make here is the difference between direct controller-to-parameter mapping strategies, as opposed to gestural recognition and mapping strategies. This project is in the process of evaluating both options given the multi-control and multi-tactile nature of the iPad. In this way research involves the systematic categorization of possible hand gestures, bearing in mind that in the case of the iPad, movement is commonly tracked at the fingertips. In this way, gestures will be separated by the number of fingers used (i.e. that is between 1 and 10.) From here it is possible to correlate those gestures commonly used for Apple OS level control and functions, and develop new strategies for control.

Whilst the iPad is currently being used to export coordinates of multi-finger movements over Wi-Fi, the way in which this data is managed is currently performed by MaxMSP. Current implementations firstly

determine the number of fingers used in the gesture. A second step involves the filtering and formatting of this information to a specific destination based on the number of fingers used, and step three involves either processing of this information, or analysis for the purposes of pattern recognition or manipulating the data into a useful format for mapping. The two examples in Figure 12 include a patch used to recognise a physical oscillation pattern, like what string players use for vibrato, and extracting information from a “pinch” gesture.

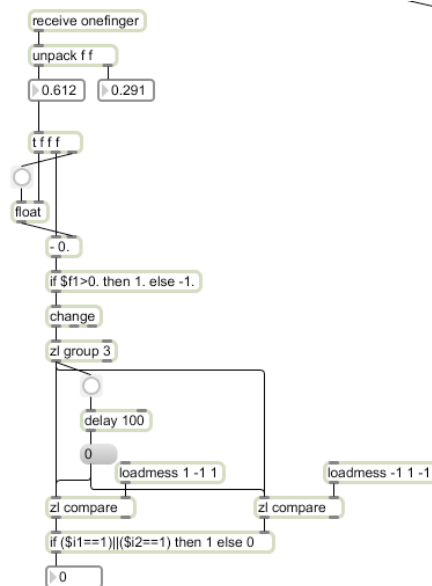


Figure 12a. A patch designed to recognise a vibrato movement.

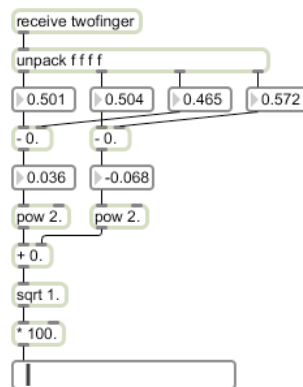


Figure 12b. A patch designed to output the distance between two fingers, ideal for when one creates a “pinch”-like gesture

Advantages for iPad integration include the option for tilt sensing, which can be measured using the

<sup>25</sup> Overholt, D. 2002. “New Musical Mappings for the MATRIX Interface.” *Proceedings of the 2002 International Computer Music Conference*. <http://www.create.ucsb.edu/~dano/matrix/ICMC2002.pdf>

<sup>26</sup> Applications currently include ProRemote, ProRemote Light, ProTransport, TrixMix, Pro-XY, MrMr, TouchOSC, ITM MidiLab, ITM Pad, c74, iOSC, iTM Tilt, Remokon for OSC, OSCemote, rain., Grid Pro, Runxt Life, Breath OSC Interface, Hex OSC S, Control, eyoControl, OSC Physics, Grid Pro, SonicLife, Ardumote HD, [v] Remote for iPad, GyrOSC, touchAble, expressionPad, Kapture Pad, DrawJong, Live Music Coder M^2 OSC, OraisonLight, dot E++, HexaChrom, and Runxt Life Plus

<sup>27</sup> TouchOSC has an editor utility downloadable from the hexler.net website allowing the user to custom design their own multi-touch control work surfaces.



accelerometer sensor built into the iPad. In this way we may be able to control the tilting of the terrain structure, resulting in spectral divergence. A two finger rotation can be mapped to the rotation of the terrain or trajectory, which then correlates with the rotating of frequencies around a multichannel array. The two-finger “pinch” can be mapped to scaling adjustments in the trajectory signal, correlating to spatial separation. Multifinger movements, that is those using between 5 and 10 fingers, can be used as geometric contortions of the terrain and trajectory structures result in effective translations spatially.

## 5. CONCLUSIONS

The focus of this paper has been to outline a new methodology for controlling timbral spatialisation, and to discuss how a gestural controller, in this case an iPad, may be used to govern the way in which Wave Terrain Synthesis controls timbral spatialisation gesturally. Whilst there is still much work to be done in regards to the gestural development and its implications on the performability of such a technique as timbral spatialisation, what is established at this point is a clear trajectory and course of action penultimately leading towards a more thorough investigation of these pertinent issues.

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